[...]partment of Agriculture Agricultural Research Service August 1992

# Agricultural Research



**The Great Plains**
**Vast, Bountiful, Fragile**

Story on page 4

# FORUM

## *ARS Excels in Public/Private Cooperation*

For many years, Agricultural Research Service scientists and administrators watched in dismay as innovative new products and technologies from ARS labs languished in relative obscurity.

Oh, ARS research findings were duly publicized by news releases, inhouse technical publications, and appropriate scientific and professional journals. The agency did what it could to encourage potential end users to pick up and develop promising food and agricultural innovations developed by ARS scientists.

And we had some notable successes. Examples include frozen and dehydrated foods processing, permanent press fabrics, corn sweetener technology, vinyl plastics stabilizers from vegetable oil, and the superabsorptive polymer called Super Slurper.

But all too often, the time lapse between the completion of laboratory research and its pickup by industry was decades—rather than months, or a few years. And the most active interest sometimes seemed to come from foreign competitors.

To help inspire U.S. companies to take advantage of more on-the-shelf research from ARS' and other federal laboratories already bought and paid for by American taxpayers, the Congress enacted the Federal Technology Transfer Act of 1986. It authorized federal agencies to enter into Cooperative Research and Development Agreements (CRADA's) with private industry and allowed for the granting of exclusive licenses for federally developed innovations.

According to U.S. Department of Commerce figures, ARS has been the federal leader in number of CRADA's signed since enactment of the law. Since inception of the ARS program 5 years ago, we have registered 241 CRADA's, formalizing 65 in just the last fiscal year. This number surpasses that of both the Department of Commerce and the Department of Health and Human Services, including the National Institutes of Health (NIH).

But ARS doesn't pursue CRADA's at the expense of the agency's specific research mission. All projects approved for CRADA's must closely pertain to research determined to be of high ARS priority and related to active research studies currently in progress.

The primary action takes place at the research unit level, for the key ingredient of each CRADA is the scientific plan of work. This is developed by the ARS researcher along with the cooperating company's technical personnel. The ARS scientist negotiates each partner's contribution to the agreement. These discussions define the technology and increase the chance of successful product development.

The ARS Office of Cooperative Interactions then coordinates the agency's CRADA development. And OCI works with the ARS ethics office to ensure that CRADA's do not pose any conflict of interest and that they give all potential cooperators a fair chance to participate in the program. Following these criteria, ARS has developed agreements with a range of cooperators, from small companies to large conglomerates.

The very first government CRADA was formalized in July 1987 between ARS and Embrex, Inc., a small Raleigh, North Carolina, firm. Embrex had already been awarded an exclusive license on an ARS patent for in-the-egg vaccination of poultry for Marek's disease. The special device injects vaccine into fertile eggs, thereby protecting chicks before hatching. The CRADA was to develop a new in-ovo vaccine to control avian coccidiosis, a growth-retarding intestinal disease costing the U.S. poultry industry about $350 million a year.

Since that first agreement was signed, ARS has entered into CRADA's on a variety of technologies addressing contemporary concerns such as food safety, biological pest control, product quality—even medicine.

Business and academic institutions are increasingly turning to ARS for CRADA partnerships. The agency projects a 25-percent increase over last year's total by the end of 1992.

These agreements aren't limited to financial assistance. The cooperating firms may contribute personnel, equipment, or proprietary materials otherwise unavailable to the agency. In many cases, they provide the know-how needed for development and commercialization of the new ARS product, process, or service.

In return, the cooperators receive the option of first rights to exclusive licenses on patented inventions generated under the agreements. And with these licenses comes also an ARS commitment to provide necessary scientific support.

This new spirit of public/private cooperation—enhanced by appropriate legislative authority—helps guarantee that both farmers and consumers benefit even more in the future from the agency's diverse and comprehensive research program.

CRADA's, patents, and exclusive licenses are doing a lot to get new ARS technologies out of the laboratory or off the shelf and into use. Products now in the marketplace because of ARS CRADA's include Embrex's in-ovo vaccine, a plant virus test kit, biodegradable plastics, and new food/fiber ingredients such as oatrim.

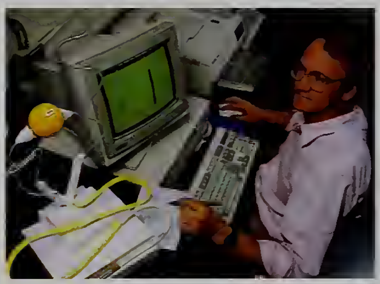
Estimates of the financial returns from these and other ARS joint public/private efforts are already in the billions!

**William H. Tallent**
Assistant Administrator
Cooperative Interactions

# Agricultural Research

Cover: **In South Dakota, a rancher inspects a few stalks of crested wheatgrass, a nutritious perennial relished by wildlife and livestock alike.** Photo © Tim McCabe

Page 10



Page 16

Page 19




Vol. 40, No. 8
August 1992

Editor: Lloyd McLaughlin (301) 504-6280
Associate Editor: Linda McElreath (301) 504-6280
Art Director: William Johnson (301) 504-5559
Contributing Editor: Jeanne Wiggen (301) 504-6785
Photo Editor: John Kucharski (301) 504-5914
Assoc. Photo Editor: Anita Daniels (301) 504-5357

Reference to commercial products and services is made with the understanding that no discrimination is intended and no endorsement by the U.S. Department of Agriculture is implied.

*Agricultural Research* is published monthly by the Agricultural Research Service, U.S. Department of Agriculture, Washington, DC 20250-2350. The Secretary of Agriculture has determined that publication of this periodical is necessary in the transaction of public business required by law. Information in this magazine is public property and may be reprinted without permission. Non-copyrighted photos are available to mass media in color transparencies or black and white prints. Order by photo number and date of magazine issue.

When writing to request address changes or deletions, please include a recent address label.

Subscription requests should be placed with New Orders, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954. Please see back cover for order form.

Address magazine inquiries or comments to: The Editor, Information Staff, Room 316, Bldg. 005, 10300 Baltimore Ave., Beltsville Agricultural Research Center-West, Beltsville, MD 20705.

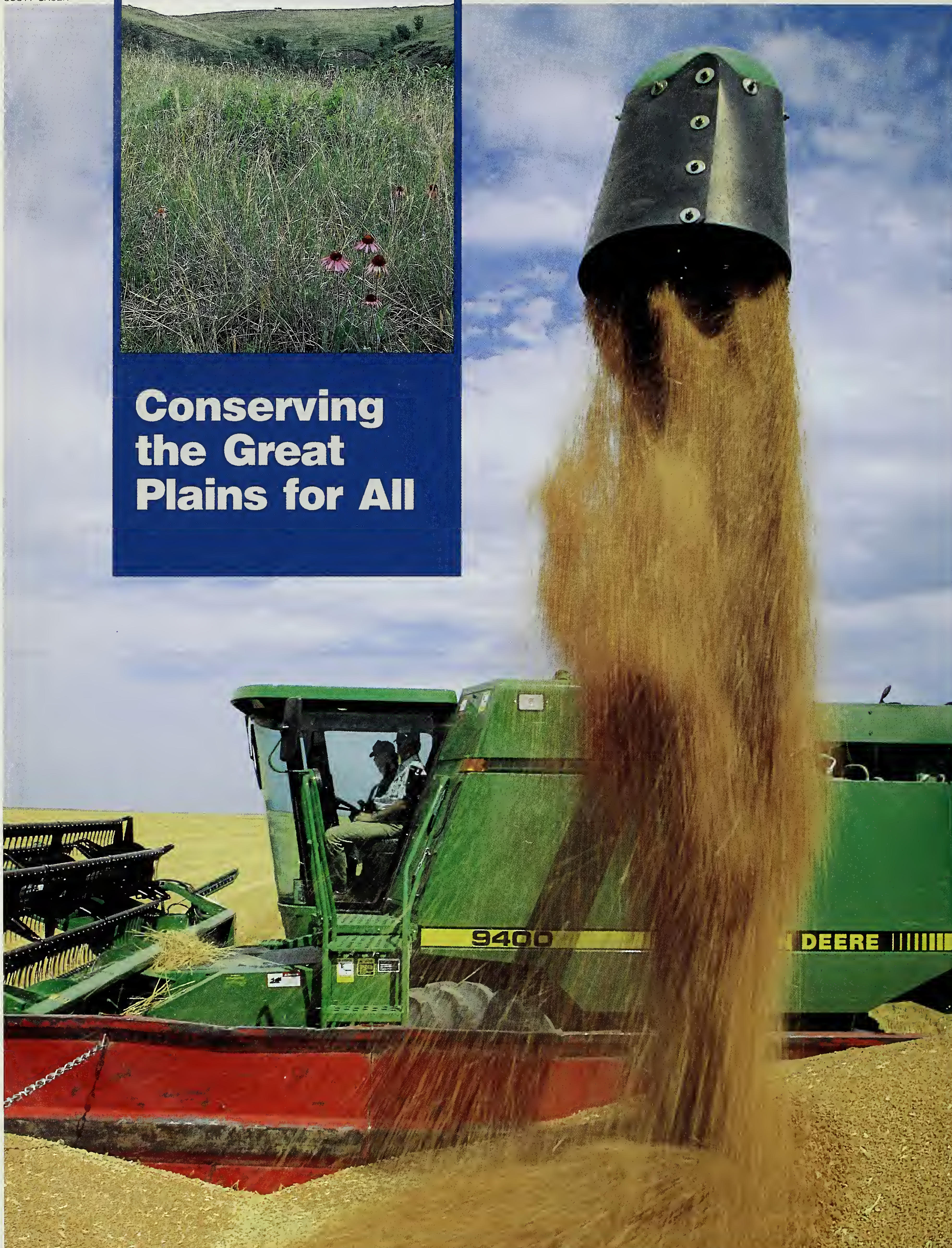
Edward Madigan, Secretary
U.S. Department of Agriculture

Duane Acker, Assistant Secretary
Science and Education

R.D. Plowman, Administrator
Agricultural Research Service

Robert W. Norton, Director
Information Staff

SCOTT BAUER




# Conserving the Great Plains for All

The Great Plains is a unique and wondrous ecosystem...harsh, yet productive...slow, but inexorable in its rate of change...unpredictable, except in its changeability.

So believes Jan van Schilfgaarde, the Agricultural Research Service's national program leader for natural resources and systems research based at the agency's Beltsville, Maryland, facility.

Van Schilfgaarde says, "Because of the harsh climate and generally low precipitation, damage done to the plains soils or vegetation tends to be slow to heal. The balance between regeneration and deterioration, between economic production and heartbreaking failure, is precarious and subtle."

"What affects agriculture affects almost everyone in this area," says James R. Welsh, Director of ARS' Natural Resources Research Center (NRRC), Fort Collins, Colorado. "For example, when farm income drops, local merchants feel the pinch, too. Tractor and truck dealers, fertilizer and seed sales people, even general merchants suffer lost or reduced sales. Farther down the line, suppliers of tractor parts and consumer goods are hurt by the reduced demand. So you might say that what's good for the Great Plains is good for America."

Farmers and ranchers in the 10 Great Plains states produce agricultural commodities that are vital to the nation's domestic and foreign markets. Agriculture is the number one industry for almost all communities in this vast area extending from northern Mexico into Canada.

The Great Plains has about a third of the total U.S. land committed to farms and ranches, but it produces more than 40 percent of America's beef cattle and more than 50 percent of its wheat. Just across the border, Canada's portion of the Great Plains makes up about 80 percent of that country's farm land.

From the dawn of agriculture about 10,000 years ago, agriculture was pretty much self-supporting, not using much fossil fuel energy or synthetic pesticides and fertilizers.

Then, along with the industrial revolution, farming changed and became more mechanized, requiring the purchase of additional inputs such as fertilizers and pesticides.

As farming systems have become more efficient in the last 100 years, the rate of agricultural impact on the land has accelerated. And soil erosion and water pollution have become serious problems for the Nation.

Soil is being lost faster than it's being created on 48 million acres from wind erosion and on an additional 28 million acres from water erosion. That represents about 70 percent of the arable acreage of the Great Plains.

In 1991, the NRRC was formed in the Colorado-Wyoming area to address excess erosion and other agricultural problems of the central Great Plains in an integrated fashion. Research units contributing to the NRRC include Water Management, Soil-Plant-Nutrient, Great Plains Systems, and Sugarbeet Production at Fort Collins; Central Plains Resources Management at Akron, Colorado; and Rangeland Resources at Cheyenne, Wyoming.

SCOTT BAUER

**The sensing unit that technician Jeff Thomas is attaching records motion and other data so scientists can determine how much time this steer spends grazing each day. (K4235-8)**

Problems to be addressed include irrigation management, range and livestock issues, dryland cropping practices, and associated environmental concerns. Solutions should lead to both increased agricultural profitability and improved natural resource preservation.

Says Welsh, "We at the NRRC hope to protect the environment and sustain productivity by using a systems approach—one in which all parts of the agricultural system are integrated into a complete computer-based

**Wheat harvest at the ARS Central Great Plains Research Station in Akron, Colorado. (K4258-9)**

information package that takes into account production, marketing, and social concerns."

### A Century's Worth of Data

A wealth of scientific information has been generated since research first began more than 100 years ago in the Great Plains. But the very nature of the data collected from diverse locations and the regional bias that influenced its gathering make its use and interpretation for other locations difficult—if not impossible.

A systems approach will permit scientists to extrapolate from these existing data sets and generate new computer models to test hypotheses critical to the survival of agriculture in semiarid and arid environments. For example, conservation tillage research done at Mandan, North Dakota, might yield information useful to farmers in Nebraska or Colorado if properly adapted through the use of these computer models.

A committee of farmers, ranchers, industry leaders, scientists, and administrators recommended creation of a Great Plains Agrisystems Project to formulate a systems approach to agricultural management. The NRRC will provide administrative and structural leadership and support for the project.

"Over the years, relatively little attention was given to collecting information in common design or compatible formats. Our first challenge will be to identify and evaluate current agricultural research data from both Canadian and U.S. groups.

"Next, we will begin building farm-level decision support systems that integrate and use various data sets that represent scientific and technological advances. Finally, the system will be tested by the intended users to evaluate its possible applications and to identify

SCOTT BAUER

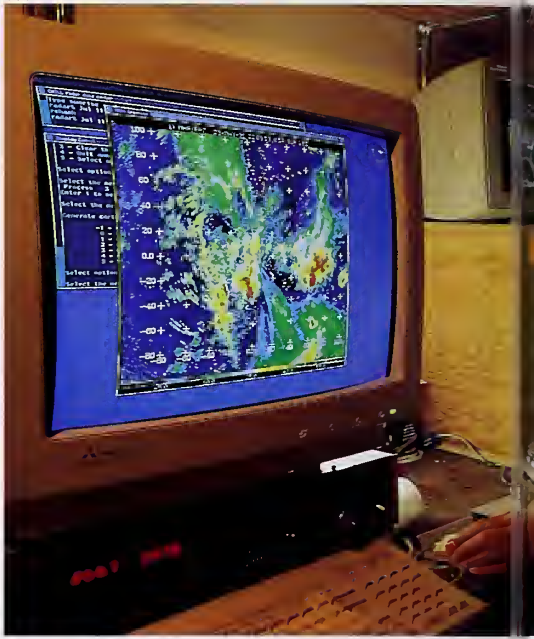
**Soil scientist Ardell Halvorson examines the effects of nitrogen fertility levels on dryland corn. (K4260-17)**

knowledge gaps requiring further research and information," says Welsh.

Systems analysts will play a major role in integrating historical databases with recently collected information. But these scientists will also coordinate their work with specialists in other fields and with end users—farmers and ranchers. The Great Plains Systems Research Unit will serve as the lead group working cooperatively with other U.S. and Canadian computer modelers in order to best use available scientific expertise.

Says Jon D. Hanson, ARS range scientist in the Great Plains Systems Research Unit, "Ranching has always been a risky industry. Profits or losses are largely determined by factors such as market demand for red meat and weather conditions—factors that ranchers have no control over."

SCOTT BAUER



**Colorado State's Pat Kennedy compares thunder-Doppler radar facility with actual rainfall figures**

Today, new variables must also be considered, including exotic breeds of cattle, new federal grazing regulations, and a host of environmental concerns such as water quality, wildlife habitats, and soil erosion.

Ranchers need a way to optimize their income for both short-term and mid-term periods that will also preserve natural resources for the long term. The systems approach will allow problems to be evaluated through computer programs, suggest alternative management choices, and spell out the potential economic impact each choice will have.

### Creating a Model System

"We are developing an Agricultural Resource Management System to help sort though millions of bits of information and to guide ranchers in making the best decisions," continues Hanson.

The central model, called SPUR II, is being developed in cooperation with Colorado State University and will be

storm data acquired by the university's collected at ARS field locations. (K4239-17)

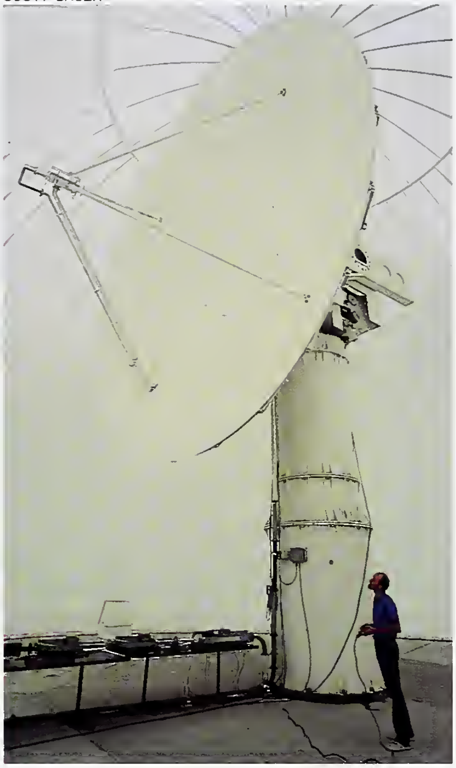
combined with two expert systems and a linear model. The combined system will be unique because it could provide ranchers with estimates of how different sets of management practices affect both long- and short-term profits and long-term productivity.

## Conserving Water

Water is a major limiting factor in Great Plains productivity. Researchers have developed computer programs that calculate the exact amount of irrigation water crops need and advise the irrigator on which pumps to use to keep energy costs low.

"In studies with multiple center pivot systems, we saved cooperating farmers $10 to $40 per acre per year because of improved water management and from about $6 to $15 in reduced energy charges," says Gerald W. Buchleiter, agricultural engineer at the NRRC's Water Management Research Unit, Fort Collins. Similar computer programs are designed to reduce water use in furrow irrigation.

SCOTT BAUER



Dwarfed by the Doppler weather radar antenna, David Brunkow of Colorado State verifies its positioning. (K4238-17)

Precipitation in the Great Plains frequently occurs in intense bursts. Often, part of a 12- to 14-inch annual rainfall—such as is normal near Nunn, Colorado—runs off rather than soaking into the soil.

"We need to find farming and ranching methods that increase water infiltration, preserving this limited resource for plant production," says Gary Frasier, hydraulic engineer at the NRRC's Rangeland Resources Research Unit, Fort Collins. So far, researchers have developed terraces, grass waterways, and plastic mulches to conserve precipitation.

Frasier is modeling the problem, using a rainfall simulator to recreate sudden, intense rain showers typical of the plains. He's looking for techniques that will increase water infiltration into soils of the area.

A method for gathering large-area precipitation data involves a state-of-the-art Doppler radar system located near Greeley, Colorado, and operated by the National Science Foundation.

In recent cooperative studies with Colorado State University, scientists used the radar to measure the intensity of rainstorms as they occurred over ARS' Central Plains Experimental Range near Nunn. Twelve rain gauges recorded rainfall while other devices measured runoff on the 16,000-acre research site.

Scientists hope to tie the radar data to the amount of water in the rain gauges. So, in the future, radar alone could measure rainfall intensity and, when used in conjunction with simulation models, predict runoff and erosion. This would eliminate the need for labor-intensive and expensive gauges.

## Replenishing Depleted Nutrients

Cultivation of prairie soil generally leads to reduced organic carbon, nitrogen, and phosphorus—the three most important elements plants need.

ARS soil scientist Rudolph A. Bowman, at the Central Plains Resources Management Research Unit, Akron, Colorado, discovered that after 60 years of cultivation, more than half of these elements have been either used up by plants or washed or blown away. And more than 30 percent of the loss occurred during the first 3 years.

"Phosphorus appears to reach an equilibrium after 20 years of tillage in which no more is lost than gained, but carbon and nitrogen continue to disappear. This loss is from sandy soils typical of the Great Plains and is a far more rapid loss than has been reported on loamy or clay soils." Bowman says.

Bowman's work is part of the larger cropping systems research program under the direction of ARS

soil scientist Ardell Halvorson at Akron. Halvorson and his team are studying alternative crops and cropping sequences to increase farming profitability beyond that yielded by conventional wheat-fallow rotation. The researchers learned that corn and millet can be grown profitably in the area and can be included in the older crop rotation.

Finding enough forage for livestock is a serious problem for ranchers in the western Great Plains. Many producers rely on hay from irrigated mountain meadows to fill this need. Fertilizer can sometimes increase yields.

Scientists at the High Plains Grasslands Research Station, Cheyenne, Wyoming, want to help ranchers make decisions about their pastures. Says ARS range scientist Richard H. Hart, "We have developed a computer program that considers variables such as temperature, cost and rate of fertilization, and price of hay. We calculated the most profitable nitrogen application rate for smooth bromegrass, creeping foxtail, meadow foxtail, and reed canarygrass at various nitrogen costs and hay prices."

However, chemicals—including fertilizers and pesticides—move downward in soil if water soaks in faster than plant roots can absorb it. Warns Carlos Alonzo, a hydraulic engineer in the Great Plains Systems Research Unit, Fort Collins, "Just how these chemicals move under differing conditions is still not completely known. So we have developed a two-dimensional model that we hope will explain subsurface transport of these potential pollutants."

### From Earth to Sky

Other chemicals move upward and have the potential to affect gases that make up our protective atmosphere. Arvin R. Mosier, an ARS chemist in the Soil-Plant-Nutrient Research Unit, Fort Collins, is studying how land use and management changes in cultivated crops and native ranges influence the soil/atmosphere exchange of gases. The three of greatest concern are carbon dioxide, methane, and nitrous oxide.

SCOTT BAUER

**Under spray from the rotating boom rainfall simulator he operates, hydraulic engineer Gary Frasier gathers information on soil infiltration and water runoff. (K4257-14)**

SCOTT BAUER

**Surrounded by protective fencing that shields the rain gauge from wind currents, hydrologic technician Michael Murphy retrieves precipitation data for a site on the 16,000-acre Central Plains Experimental Range. (K4261-1)**

These so-called greenhouse gases influence how much energy is absorbed by or radiated away from our planet and its atmosphere. The concentration of these gases is increasing rapidly in the atmosphere. Nitrous oxide also plays a role in destroying the stratospheric ozone layer.

"Our studies indicate that changes in land use have probably contributed to the increasing atmospheric concentrations of greenhouse gases during the past century," says Mosier. "Agricultural management practices also influence the soil/atmosphere exchange of all three gases. Practices that conserve soil and fertilizer generally decrease nitrous oxide emissions from soil and influence carbon dioxide and methane exchange as well.

"We need to be on top of the situation, prepared to cope with potential changes in the environment,"concludes Mosier. "We are developing computer models that can analyze the effect of various shifts in temperature and atmospheric gases. This will give farmers and ranchers some understanding of what management practices will work best under these new conditions."

These and many other research projects in the NRRC have been sources of valuable information for the systems approach to Great Plains issues. Moreover, public research programs—both ARS and land-grant university—across the Great Plains have historically produced findings important to solving complex agricultural questions.

"It is vital that we take the next step in integrating this information to ensure viability for future agricultural enterprises," adds NRRC's director, James Welsh.—By **Dennis Senft,** ARS.

*James R. Welsh is at the USDA-ARS Natural Resources Research Center, 1701 Center Ave., Fort Collins, CO 80526. Phone (303) 498-4227.* ◆

## Settling the Plains

Major Stephen B. Long crossed the Great Plains in 1819 and 1820, noting in his diary that the area was the Great American Desert. Others followed him but did not settle in the area because it lacked the trees and water so familiar in the eastern United States.

Agricultural development of the plains in Colorado began in the 1860's near the mountains. Those first farmers supplied food to thriving mining communities. Large livestock herds from Texas were summer grazed in the area starting in the late 1870's. The open-range cattle industry peaked in the mid-1880's but soon declined after a severe winter in 1886.

About the same time, homesteaders attempted dryland farming, only to abandon the land during a severe drought in the mid-1890's.

Plains settlements grew slowly until World War I, when a sudden surge in demand for wheat turned native rangeland into instant farms. Mechanized farming enabled cultivation of large acreages of dryland wheat.

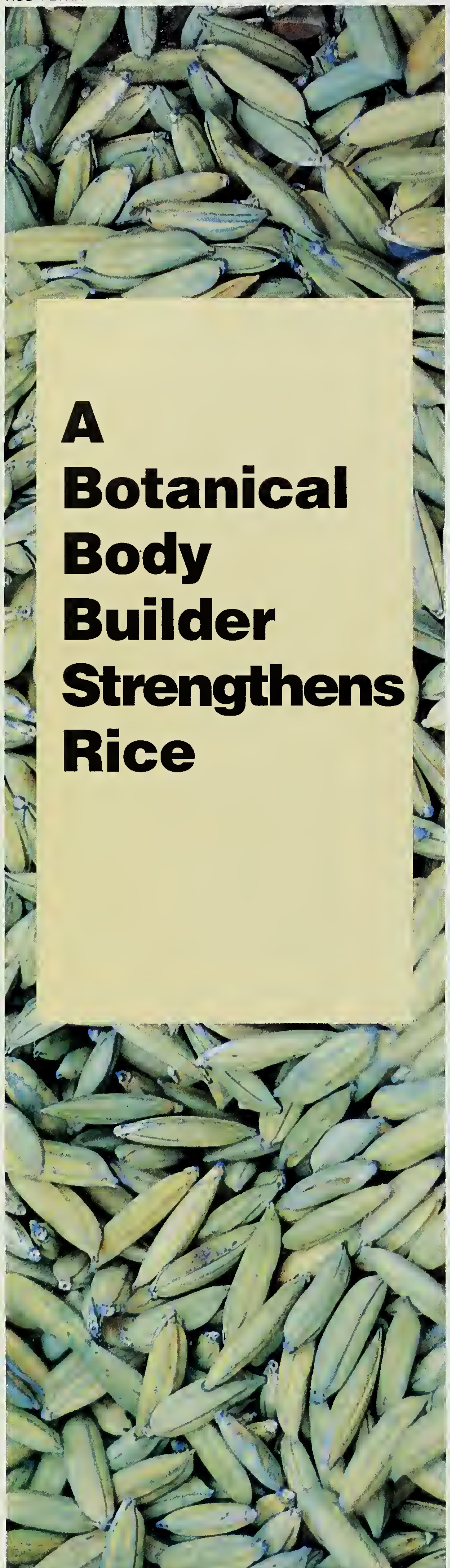
During the 1930's, drought and the Great Depression caused the abandonment of hundreds of thousands of acres of dryland farms, setting in motion the creation of a vast Dust Bowl that sometimes darkened the skies of downwind cities as far away as New York City.

But World War II saw the demand for wheat increase once again, and Great Plains lands were plowed to meet the demand. The most recent increase in grassland conversion occurred in the late 1970's and early 1980's.

*Excerpted from "Changes in Vegetation and Land Use in Eastern Colorado, A Photographic Study, 1904-1986," (ARS-85, Sept. 1991), by William J. McGinnies. The book is out of print, but photocopies and microfiche are available from the National Technical Information Service (5285 Port Royal Road, Springfield, VA 22161), stock no. PB 92133776.*

# A Botanical Body Builder Strengthens Rice

ROB FLYNN



**Rice seeds with gibberellic acid added are dyed green to indicate that they have been treated. (K4739-19)**

Southern rice farmers are getting a financial boost these days from a slightly offbeat source: weight-lifting rice plants.

In lab tests, the strapping seedlings have pushed up plastic plungers loaded down with as many as four 1.2-gram metal washers, researchers report.

There's nothing magical about the plants themselves; they're ordinary semi-dwarf rice varieties used by farmers since the early 1980's. But like the cartoon character Popeye with his cans of muscle-building spinach, the germinating rice seeds get extra "oomph" from a natural product—a growth regulator called gibberellic acid (GA) that elongates emerging plant parts.

The weight-lifting plants are more than just a laboratory oddity. The extraordinary elongation and pushing power derived from the gibberellic acid ensure that after germination, the new rice plants will be able to push up through the soil on time and generally in unison—attributes of significant economic value to farmers, according to ARS geneticist Robert H. Dilday.

"In growing rice, you use emergence of the plants as a point from which to calculate when to do a lot of other things, such as applying fertilizer or herbicides," says Dilday, who works in the ARS Rice Production and Weed Control Research Unit at Stuttgart, Arkansas.

"If emergence is spread out over several weeks, it's hard for the farmer to figure out the right time to take those other actions.

"Also, timing of emergence can affect timing of harvest, which in turn affects the quality of the rice. The farmer needs to harvest rice when the moisture content of the grain is about 18 percent," says Dilday.

"If the rice is at different stages when you harvest it, you may get some rice with less moisture than that. Then you can wind up with a lot more broken kernels, and broken kernels are only worth about half as much as whole kernels."

Semi-dwarf rice varieties such as Lemont and Gulfmont have won favor with farmers because the shorter plant stems are less likely to break and dump valuable grain on the ground. In Arkansas, the nation's top rice-producing state, the Lemont variety alone has claimed about 20 percent of all rice acreage.

But farmers were also quick to discover the major drawback of semi-dwarf rice: its difficulty in emerging from the soil after planting.

When a rice seed germinates, plant parts called the mesocotyl and coleoptile are the first to push forth. Once the coleoptile has broken through the soil to sunlight, leaf growth begins.

But if seeds of semi-dwarf rice are planted even one-quarter inch too deep, the coleoptiles may not be able to reach the soil surface, leaving farmers with a spotty or nonexistent crop.

## Gibberellic Acid to the Rescue!

In lab studies begun in 1988, Dilday and agronomist Ronnie S. Helms of the University of Arkansas tried treating semi-dwarf rice seed with a type of gibberellic acid called GA3. Seeds were soaked in the growth regulator at rates of 10, 50, or 100 parts per million for about 5 minutes.

When planted, the treated seeds sent shoots barreling upward to the soil surface. In some instances, Dilday says, the lengths of the mesocotyl and coleoptile were actually doubled.

Pushing power is especially important on Arkansas' Grand Prairie, heart of the state's rice-producing area. When spring rains pummel the silty clay loam soils of the prairie, tough crusts half an inch thick can form on the soil surface.

But even the treated seed needs a little help from nature—notably, soil temperatures warm enough to encourage germination.

"If you plant this treated seed when the soil temperature is about 58°F, which is fairly typical for late April and early May, you'll see an increase in germination of 2 to 30 percent with the treated seed versus untreated semi-dwarf seed," notes Helms.

acres of GA-treated rice," says Dilday. "Arkansas farmers planted about 350,000 acres of that total, and we think this year's total in Arkansas alone may be 500,000."

The GA treatment now available commercially to farmers is the result of

on rice in one field and it came up really quick," he recalls. "Then we had a wet spell, and as soon as they could, they went back and replanted their other fields with treated seed."

David W. Hillman, who grows rice, soybeans, and wheat at Almyra,

ROB FLYNN

**Two weeks after planting, plant geneticist Robert Dilday surveys a test area planted with rice seeds not treated with gibberellic acid. Seedlings are smaller and fewer in number than the areas to the left and rear where the seeds were treated. (K4742-18)**

"On some varieties, we've seen seven more plants per square foot emerge when treated seed was used. And there's no detrimental effect to this treatment."

The treatment is designed for rice planted into dry land, as opposed to planting on land that's already been flooded, the practice followed in California and parts of Louisiana.

Among rice farmers who use the dry-seeded method, the GA seed treatment is a hit, as evidenced by their seed purchases.

"We estimate that in 1991 in the South alone, farmers planted 500,000

technology transfer between ARS and Abbott Laboratories of Chicago, Illinois. Dilday and Helms worked with Abbott's Rollie Carlson and Marcus Adair on field and laboratory tests to evaluate the potential of the product, now marketed by Abbott under the brand name Release.

Part of the credit for GA's wildfire spread among farmers must go to Ronnie Helms, who passed the word on GA treatments at some three dozen growers' meetings in the winter of 1990-91.

Helms says even he was impressed by the farmers' reactions. "I know of some farmers who used this treatment

Arkansas, first used the treatment solely on an experimental basis on some of his Lemont rice fields.

"Lemont has been known to have trouble emerging when you plant too deep," Hillman says. "It's very important for maximum yields that the plants all come up at the same time. Ideally, rice should come up in a 3- to 4-day period. But with Lemont, some plants would come up in a few days, and others 2 weeks later.

"Because of this, we normally try to have an ideal seedbed, soil moisture just right, and we take a lot of time setting

ROB FLYNN

**Rice growers Kenneth Maier (left) and David Hillman (center) receive technical assistance on planting gibberellic-acid treated rice from extension specialist Ronnie Helms. (K4742-1)**

the depth of our seed drill when we plant Lemont.

"We'd planted part of a field under what we considered ideal conditions, with the seed down about half an inch. Then the guys came out to plant the treated seed, and they put those seed down 3 inches! But 3 days later, every single stalk came up—ours and theirs."

Hillman says every acre of his Lemont production this year features GA-treated seed, despite the extra expense of the treatment. And, he adds, some of his neighboring farmers wish they could go even further: "I've heard some ask, why can't we use this on wheat seed, too?"

Neighbors had a lot to do with persuading farmer Kenneth R. Maier of Stuttgart to give the treatment a try in 1990—even though they never said a word to him about it.

"They had an experimental plot of the treated seed out the year before and I watched that plot," says Maier. "It was right by the road and as I drove by, I could see how it came up in a good, even stand."

As a result of what he saw, Maier planted 200 acres of treated semi-dwarf rice in 1990, and "it did what they said it would do—came up early in a good stand.

"It's hard to get rice planted all even; you're always afraid you've got the seed too deep," Maier notes. "But with this treatment, you don't have that pressure—and you can plant down deep where the soil moisture is."

Nor are farmers the only satisfied customers for the GA treatment. At Stratton Seed Co. in Stuttgart, company president Wendell Stratton says demand for the seed treatment has been impressive.

"We treated quite a bit more last year than we had anticipated, and not just the semi-dwarf varieties," he says. "I think usage on the non-semi-dwarf rice will taper off a little bit, but I think this practice will continue to grow on the semi-dwarf rice.

"This gives the farmer a higher yield potential because the stand won't be uneven," he adds. "And as tight as things are for farmers today, we need all the production tools we can get.

"This treatment has completely lived up to its promises. It's done everything that Bob Dilday and the Extension and university people have said it would do."—By **Sandy Miller Hays,** ARS

*Robert H. Dilday is in the USDA-ARS Rice Production and Weed Control Research Unit, P.O. Box 287, Stuttgart, AR 72160. Phone (501) 673-2661.* ◆

# Great Grapes!

## Getting Rid of Sulfite Residues

Keeping grapes free of unwanted sulfite residues should be easier, thanks to a new idea from an ARS scientist.

Packinghouse managers can now use slender glass tubes resembling small thermometers to accurately measure how much sulfite-producing sulfur dioxide reaches boxes of grapes stacked in cold storage, says Joseph L. Smilanick. He is with ARS at Fresno, California.

Applied as a gas, sulfur dioxide protects grapes from botrytis, an unattractive gray mold. Because some consumers are allergic to sulfites, however, federal law stipulates that sulfite residues on grapes must not exceed 10 parts per million—the equivalent of 10 ounces in 31 tons.

With routine sulfur dioxide fumigation, grapes like Thompson Seedless, Flame Seedless, or Emperor can stay fresh in refrigerated storage for as long as 5 months.

JACK DYKINGA

**Botrytis rot has taken its toll on grapes stored in a test warehouse. Plant pathologist Joe Smilanick evaluates the effects. (K4576-14)**

"That's why you can buy late-summer grapes from California in December," Smilanick says. Without fumigation, grapes could be stored for only about 3 weeks before succumbing to rot.

Sulfur dioxide gas dissipates quickly, so warehouse managers usually need to fumigate grapes at least once a week, typically for about half an hour. In a cold storage room packed with hundreds of boxes of grapes, though, tracking the fruit's exposure to the fumigant is difficult.

Packers who now rely on the glass tubes for the task find them cheaper and more convenient to use than more sophisticated instruments.

Known as dosimeter tubes, the devices cost about $4. Tubes placed at the top, middle, or bottom of randomly selected stacks of crates or cartons of grapes will record the amount of fumigant that circulates through the storage room. This monitoring helps protect grapes from getting too little fumigant and consumers from getting too much.

The tubes are easy to use and read. They're packed with chemically treated beads of silica gel. The chemical turns the beads yellow when it comes in contact with sulfur dioxide.

"You snap off the tops of the tubes so the fumigant can get inside," says Smilanick. "Then you put the tubes in the cartons. After you've finished fumigating, you remove all the tubes and read them just like a thermometer. But instead of looking for a red or silver column, you're reading a yellow band."

Smilanick's new idea is just one spin-off from a 3-year study by a team of ARS and university researchers, growers, and Cooperative Extension specialists who are scrutinizing each step of grape fumigation. The group wants to ensure worker and consumer safety, slash costs, and limit escape of sulfur dioxide into the environment.

They've run tests in some two dozen commercial cold storage houses in central California. "Fumigation hasn't changed much since the 1930's," says Smilanick. "We're looking for ways to streamline it."

In earlier recommendations, the team pinpointed adjustments that storehouse managers need to make to accommodate differences in type of crates or cartons grapes are stored in. Traditional wooden crates, for example, absorb fumigant differently than the newer polystyrene foam cartons. Until the team's studies, however, most packinghouses used guidelines based on the wooden crates.

The California Table Grape Commission funded part of the research.—By **Marcia Wood,** ARS.

*Joseph L. Smilanick is with the USDA-ARS Horticultural Crops Research Laboratory, 2021 S. Peach Ave., Fresno, CA 93727. Phone (209) 453-3084.* ◆

JACK DYKINGA


**To record the amount of fumigant circulating through the warehouse, technician Delmer Henson places dosimeter tubes in randomly selected cartons of grapes. (K4575-12)**

# Weevils, Mites May Thwart Gorse's Spread

SCOTT BAUER

Entomologist David Perkins beats the bushes for insects that feed on gorse. (K4271-5) (Inset K4271-10)

Thick, tough, and thorny, a hardy shrub known as gorse is nature's own barbed wire fencing. Hedges and thickets of the rugged yellow-flowered plant are nearly impenetrable.

Native to western Europe, the weed flourishes in the coastal climates of northern California, southern Oregon, and Washington, and on some islands in Hawaii.

Though sheep and goats can graze gorse's tender new foliage, it quickly crowds out other plants that are better forage. And in parklands, spines can spear unwary hikers and campers, says research entomologist B. David Perkins. He recently retired from ARS but still collaborates with the agency at the ARS Western Regional Research Center, Albany, California.

In the United States and abroad, Perkins has sought natural enemies of gorse—insects and mites, for example. Perkins and colleague Luca Fornasari have scrutinized gorse plants along roadsides and in fields and pastures in Italy, France, Spain, and Portugal. Fornasari is at the ARS European Biological Control Laboratory in Montpellier, France,

The best find from the expeditions may be a seed weevil the researchers brought back from western Spain. The weevil eats seeds growing inside gorse's beanlike pods. Scientists at ARS' Systematic Entomology Laboratory at the Smithsonian Institution, Washington, D.C., are now trying to identify the insect.

Oregon funded part of the search. The State ranks gorse as its number one worst weed.

A tiny spider mite known as *Tetranychus lintearius* may prove another potential recruit. It has already been put to work fighting gorse in New Zealand, where farming and forestry industries spend about $9 million a year to control the weed. "Anyone who doubts the potential for gorse to get out of control in the United States should look at New Zealand," comments Perkins.

The beneficial spider mites are so tiny that about a thousand of them could fit on a single, inch-long gorse thorn. Mites damage the plant by sucking juices from the weed's leaves.

While in New Zealand, Perkins let the mites sample some specimens of American gorse and other plants from the western United States. These tests indicated the mites will feed voraciously on our gorse. Fortunately, they won't harm other greenery Perkins offered, including

several native California lupines—distant gorse relatives.

With further testing and government approvals, the weevil and mite—and perhaps additional candidates—may eventually be turned loose in the United States. They would augment the efforts of other insects that feed on gorse. Those include a weevil, *Apion ulicis,* and a moth, *Agonopterix nervosa.*

The *A. ulicis* weevil is "about the size of a pen tip," says ARS botanist Charles E. Turner, who has examined the insect in California gorse thickets. It lays its eggs in gorse's hairy seed pods. Eggs hatch into wormlike larvae that feed on the developing seeds.

Colonies of *A. ulicis* have managed to destroy more than 30 percent of the aboveground gorse seeds on some sites in California and Hawaii and 90 percent of the seeds checked in a Washington State survey.

But the weevil hasn't stopped the spread of gorse thickets in America. Explains Perkins, "The major problem is that the weevil doesn't attack seeds hidden in soil, which may remain alive for as long as 30 years."

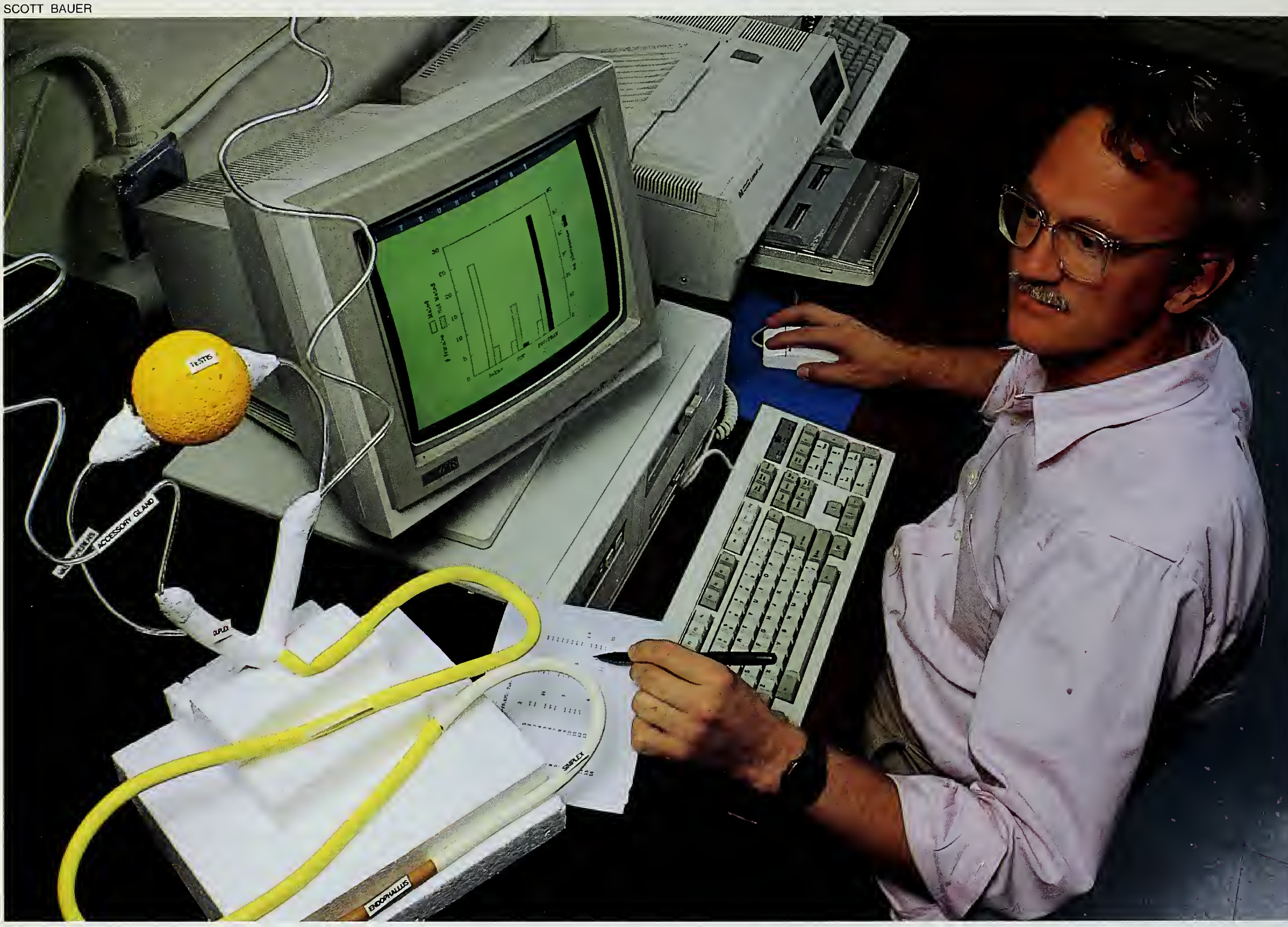
The insect may offer another avenue of attack, however. Perkins has found a mysterious apricot- or rust-colored fungus on some gorse seed pods he inspected in California. The fungus, after entering holes chewed by the female weevil before she inserts her eggs, causes seeds to shrivel and die.

No one quite knows how another gorse foe, the *A. nervosa* moth, ended up on the West Coast. About one-third-inch in size, the moth has blotchy beige and grey wings. Its larvae eat gorse's young green shoots. If left alone, those shoots would form hard spines.

Some of the gorse Perkins examined in California had 25 to 50 percent of new shoots infested by the tiny larvae. That's still not enough to hold back the weed, though. Perkins says it will likely take an assortment of enemies—perhaps each with its own unique way of causing damage—to stop the stubborn shrub.—By **Marcia Wood,** ARS.

*B. David Perkins and Charles E. Turner are at the USDA-ARS Plant Protection Research Unit, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. Phone (510) 559-5705 (Perkins) or 559-5975 (Turner). Luca Fornasari is with the USDA-ARS European Biological Control Laboratory, BP 4168, Agropolis, 34092, Montpellier, Cedex 5, France. Phone 33 67 04 56 00.* ◆

SCOTT BAUER




**Biochemist Tim Kingan analyses data depicting the behavioral effects of special proteins transferred from male corn earworm moths to females during mating. To his left is a plastic model of the male's reproductive system. (K4759-11)**

# Special Protein in Insect Sperm Is a Turnoff

A corn earworm female won't mate until she knows there are nearby plants her offspring can eat. And when she does mate, the male passes along not only sperm but also a protein that stops her from luring other males—and that may also cause her to lose interest in sex until she lays her eggs.

Causing corn earworm females to lose interest in sex is of great interest to U.S. Department of Agriculture scientists trying to control the pest, which damages an estimated $1.2 billion in crops each year. The potential payoff: new substances to control the pest without using chemicals.

The findings are firsts and were made by a team of scientists led by Ashok Raina, an entomologist with USDA's Agricultural Research Service. Much of Raina's work in recent years has centered on an insect brain protein called PBAN. Such brain proteins are known as neuropeptides.

PBAN is a neuropeptide composed of 33 amino acids—the basic building blocks of proteins. PBAN triggers production of sex attractant in the corn earworm female. She uses the attractant, called a pheromone, to lure males during nighttime mating. But she doesn't produce the pheromone until

she senses plant chemicals signaling that the right plant—such as corn—is available for her offspring to feed on, according to the research by Raina and ARS colleagues Timothy G. Kingan and Autar K. Mattoo.

"That's because, once she becomes pregnant, she can't hold back her eggs," Raina says. "So she first has to make sure there's a food source for her offspring before she mates."

Once she's found a host plant, PBAN triggers production of the pheromone and a male comes to mate. He transmits sperm and a male-specific protein called pheromonostatic peptide (PSP), which "appears to interfere with the action of PBAN—so she can't produce any more pheromone to attract other males once she's mated. It's nature's way of ensuring that she'll concentrate on laying her eggs and won't be distracted by other males once she's pregnant."

Raina says he and Kingan, at the ARS Insect Neurobiology and Hormone Laboratory in Beltsville, Maryland, in collaboration with Wanda Bodnar and Donald Hunt of the University of Virginia, have identified the sequence of 57 amino acids that make up the PSP protein. Next, he says, scientists will synthesize the protein in the lab and test it to confirm its action.

Their ultimate goal is to find a way to transmit the male protein to corn earworm females to block their mating patterns. That could be done, Raina says, by inserting the desired protein-producing gene into a special insect virus called a baculovirus and then exposing the insects to the virus—which is specific only to the insect and would not harm other insects, plants, or animals.

Minh-Tam Davis in Raina's lab cloned the PBAN gene, and Raina, in collaboration with Vic Vakharia of the Center for Agricultural Biotechnology, University of Maryland, successfully inserted the PBAN gene into a baculovirus.

That's a "model system" for getting the protein inside the insect, Raina says, "because you can't spray or feed a protein like you can an insecticide."

How corn earworms regulate the production of sex attractants was a mystery until Raina's discovery that a neuropeptide was involved. Raina and colleagues then spent about 5 more years identifying PBAN's specific protein composition. Howard Jaffe, formerly with ARS and now at the National Institutes of Health, worked on purifying PBAN, while Thomas G. Kempe, who is at the University of Maryland, collaborated on synthesizing it.

**The potential payoff from neuropeptides research is controlling the pest without using chemicals.**

That effort paid off in July 1991, when Raina and two collaborators received a patent on PBAN—clearing the way for companies to seek licenses to turn the protein into a new, natural corn earworm control to replace chemicals.

Aside from the baculovirus approach, Raina and Kempe are also pursuing another strategy: The production of nonprotein mimics to act as blockers of PBAN action and disrupt the insect's internal body functions. They identified a short protein fragment consisting of only five amino acids. The fragment had the same effect on the insect as the intact PBAN. Then the two designed a PBAN-fragment mimic consisting of just one amino acid.

Mimics are important because they break down more slowly than proteins inside the insect's body, making them effective longer.

The next step will be finding a PBAN blocker to disrupt corn earworm mating. It could be a nonprotein mimic that could be sprayed on the insect. Or it could be a protein—such as the male PSP protein—that would be synthesized and then inserted into the baculovirus.

In either case, the result would be bad news for the insect's sex life—but good news for farmers.—By **Sean Adams,** ARS.

SCOTT BAUER

**Entomologist Ashok Raina observes mating behavior of a corn earworm female exposed to volatile chemicals from corn silk. (K4759-1)**

*Ashok K. Raina is with the USDA-ARS Insect Neurobiology and Hormone Laboratory, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 504-9396.* ◆

HERB PILCHER

Geneticist Glenn Burton examines Tifton 85, the newest, improved bermudagrass developed for livestock forage.

# Cattle Gain Faster on Tifton 85

## New bermudagrass hybrid has enhanced digestibility

When the spriggers heard about the new bermudagrass, it wasn't long before Earl Elsner's telephone began ringing.

"I started getting telephone calls the next day, saying, 'I want some, I want some,' " recollects Elsner, director of the Georgia Seed Development Commission, which distributes seeds and cuttings to certified growers.

The spriggers—who plant grass in clumps called sprigs—were excited by a report from a research team led by Agricultural Research Service scientist Glenn W. Burton. During a late-February workshop in Tifton, Georgia, Burton and colleagues Roger N. Gates and Gary Hill told the spriggers about Tifton 85, which ARS and the University of Georgia had recently released.

Tifton 85 is the newest of ever-improving bermudagrass varieties developed by the ARS Forage and Turf Research Unit at Tifton. The group is headed by Burton, a research geneticist. During his 56 years with USDA, Burton's group at Tifton has developed several bermudagrasses—including Tifton 78, Tifton 44, and Coastal—that are widely grown across the South.

Tifton 85 was jointly developed by Burton, Gates, an ARS agronomist in Burton's unit at Tifton, and Hill, a University of Georgia animal scientist. All are based at the Georgia Coastal Plain Experiment Station in Tifton.

Suitable for pasture or hay, Tifton 85 is a hybrid between a South African variety and another called Tifton 68. The new variety is taller and has larger stems, broader leaves, and darker green color than either of its predecessors.

Because Tifton 85 doesn't produce seeds, it's grown by planting sprigs—clumps that include above-ground runners known as stolons and underground runners called rhizomes. The stolons and rhizomes spread horizontally and develop roots and a new plant at each joint.

The spriggers are excited about Tifton 85 because it has several key advantages over other bermudagrasses. During field studies from 1985-91, it produced an average of 26 percent more dry matter than Coastal bermudagrass, the popular variety first released in 1943 and now planted on 10 million acres across the southern United States.

GLENN BURTON

At Tifton, Georgia, cattle graze on the lush growth of Tifton 85 bermudagrass.

Also, in small-plot experiments, Tifton 85 was 11 percent higher than Coastal in digestibility—meaning cattle eating Tifton 85 forage could gain weight at a faster rate. This was illustrated in a 1989-91 steer grazing study, in which available forage was maintained at 2,500 pounds per acre in Tifton 78 and Tifton 85 pastures. Tifton 85 provided 38 percent more steer grazing days per acre and produced 47 percent more liveweight gain than the Tifton 78, another highly productive bermudagrass hybrid grown in the South.

"This new grass has great potential across the South," says Burton. "Bermudagrasses occupy more than half the pasture acreage in the southern United States. Much of that acreage is suitable for Tifton 85."

Hill, who presented data on the grass at a southern regional animal science meeting in Kentucky in February, says, "There was a lot of interest. Everyone was pleasantly surprised that it did so well in our field studies compared with Tifton 78."

Tifton 85 is also drought tolerant—"at least as drought tolerant as any of the hybrid bermudagrasses," said Hill. He noted that in 1990—Georgia's worst drought year since 1954—there were no apparent losses and "cattle continued to graze on it at high stocking rates."

One of the few remaining questions about Tifton 85 is its ability to withstand cold. In December 1989, it survived unusually low temperatures of 7°F to 28°F in Athens, Georgia, but it was planted at a depth of 4 inches—double the normal depth. Burton is conducting further studies to determine if deeper planting depths will protect it from freezing temperatures.

Although planting may be limited to the Deep South, the researchers say it could be grown across the southern United States from Georgia to California. Elsner says spriggers from a half-dozen states—including Florida, Georgia, Alabama, South Carolina, and North Carolina—attended the workshop last February. He expects sprigs of Tifton 85 to be available from certified seed growers on a limited basis in 1993.

Cattle ranchers who want Tifton 85 sprigs should contact the crop improvement association in their state for the names of certified sprig producers.—By **Sean Adams,** ARS.

*Glenn W. Burton and Roger N. Gates are in the USDA-ARS Forage and Turf Research Unit, Coastal Plain Experiment Station, P.O. Box 748, Tifton, GA 31793. Phone (912) 386-3353.* ◆

# Of Poplar Twigs and Organ Transplants

Why is a scientist with the American Red Cross visiting an Agricultural Research Service laboratory to study frozen twigs from poplar trees?

"Very few higher plants survive cold temperatures as well as poplar trees do," says Allen G. Hirsh of the American Red Cross Transplantation Laboratory in Rockville, Maryland.

"We think we can learn a lot from the cells of poplar trees," he says, "that will help us freeze and preserve human kidneys and possibly other donated organs for future transplant operations."

Successful techniques for preserving major human organs in a frozen state have yet to be developed, according to Hirsh, because ice crystals invariably form within the tissue and destroy it. Antifreeze solutions are being tested, but so far those strong enough to block the ice formation are toxic to tissue.

"It's tragic," he says, "but many organs donated for transplant are never used, simply because they can't be stored long enough for matching to a suitable recipient."

To investigate the superior cold tolerance capabilities of poplar tree cells, Hirsh—one of two plant physiologists in the Transplantation Laboratory—is working informally with scientists at the ARS Electron Microscopy Laboratory (EML) in Beltsville, Maryland.

William P. Wergin, head of the EML, says that electron microscopy imaging techniques developed by ARS are giving Hirsh and other scientists a better look at the structural details of plant cells and other living tissue. [See *Agricultural Research,* November 1990, pp. 18-21.]

"Preparing frozen twigs for imaging by an electron microscope is no simple matter," Wergin says, "and one of our scientific staff, Eric Erbe, has done some remarkable work in this area."

SCOTT BAUER

**American Red Cross researcher Allen Hirsh prepares a poplar twig sample for observation under an electron microscope. (K4721-1)**

**Right: A poplar twig sample is trimmed for the electron microscope while still immersed in liquid nitrogen. (K4721-2)**

ERIC ERBE

**An image captured on the electron microscope reveals evidence of intracellular freezing (black holes) in a poplar twig cooled at 2°F per hour down to temperatures below minus 5°F.**

Hirsh agrees but takes it further. "I doubt that any other scientist in the United States has the skill or experience to get the kind of images of frozen woody tissue that we need," he says. "The techniques mastered by Eric Erbe have made it possible for us to make some highly important discoveries."

Hirsh found, for example, that ice crystals can form inside the cells of actively growing woody tissue—even when it's been cooled and frozen very slowly.

The prevailing view holds that under such conditions, ice in woody tissue would form only in cell walls or intercellular air spaces between the walls. However, images from the EML indicate the formation of tiny ice crystals in the cell's cytoplasm, beneath the plasma membrane that lies inside

# Electron Microscopy Technology
## Russell L. Steere—A pioneer in the field

Electron microscopy has advanced considerably since coming into general use nearly 50 years ago. This applies to the preparation of biological specimens for examination as well as to the technology itself. Without certain innovations in tissue preparation, researchers in the life sciences could not have taken full advantage of the increasingly powerful and versatile electron microscopes available to them.

Perhaps foremost among the many developments in tissue preparation was the invention of freeze etching by the late Russell L. Steere, a botanist and internationally recognized authority on plant virology and biophysics who retired from ARS in 1984.

Freeze etching, the technique used by Eric Erbe to prepare frozen poplar tissue for examination by an electron microscope, allows scientists to see thin cross sections of frozen cells in great detail.

After a frozen cell is cracked open and partially dehydrated through a freeze-drying process, Erbe explains, ice inside the cell is etched away to expose internal particles and structures. Ultra-thin films of metal and carbon are then deposited on the fractured cell like a microscopic cast. The actual cell material is dissolved with acid, leaving an exact replica of the fractured cell for placement in an electron microscope.

Steere pioneered freeze etching in the mid-1950's as a scientist with the University of California at Berkeley. His use of the technique to obtain detailed electron micrographs of tobacco mosaic virus (TMV) crystals stands as a landmark in electron microscopy. And it's one of the things that brought him to ARS in 1959 to help establish the agency's Plant Virology Laboratory in Beltsville.

As head of the laboratory, Steere initially concentrated on the isolation and purification of TMV and other plant viruses for research purposes. By the late 1960's, however, electron microscopy had become a critical tool in the lab's mission. So Steere returned to his labor of love: the perfection of freeze etching procedures and techniques.

The next 15 years saw a series of variations, refinements, and improvements to freeze etching that paralleled a dramatic growth in electron microscope technology. Much of this research on freeze etching was done by Steere in collaboration with Eric Erbe, who came to work in Steere's lab in 1970 while a student at the University of Maryland.

"Russell Steere was the single most influential person in my life," says Erbe, who as a high school junior first met the scientist in a school science club that Steere had organized.

"He did a lot of things like that for young people who were interested in science," Erbe says. "He was our friend, as well as our mentor, and I know I'm not the only one he inspired to pursue a scientific career."

Throughout the 1970's and well into the 1980's, Erbe and Steere co-authored 34 publications on electron microscopy, especially as it involved freeze etching of cellular tissue. Even after Steere's retirement, the two frequently met to review Erbe's latest work and to discuss new developments in the field.

"Yes, he always treated me like a full colleague and partner," says Erbe. "But make no mistake about it—he was the teacher. He introduced me to the whole field of electron microscopy and guided me every step of the way. What I know, I learned from him."—By **Stephen Carl Miller**, ARS.

the cell wall, even at reduction rates of less than 2°F per hour.

"I think our evidence is pretty conclusive," says Hirsh as he displays an electron micrograph of the plasma membrane of a slowly frozen poplar cell. The holes and ruptures caused by ice formed during freezing of the cytoplasm are clearly visible.

PERRY RECH

**Botanist Eric Erbe coats poplar twig samples with an ultra-thin platinum layer and a second layer of carbon for imaging with a scanning electron microscope. (K3795-20)**

"If this happens to cells from poplar trees," he says, "imagine what it could mean for animal and human tissue in which the cells have no walls and are simply stuck to one another. It certainly strengthens the case that ice could form inside kidney cells and destroy them — regardless of how slowly the tissue is cooled."

Some scientists maintain that small amounts of ice in human organs might be tolerable during long-term storage, notes Hirsh, and that research in cryogenic preservation need not strive to entirely eliminate ice formation.

"Quite frankly, I think they're badly mistaken," he says. "Judging from the ice damage we've seen in poplar cells, I doubt that allowing ice to form at any level in human tissue is going to be part of the answer."

## Is there an answer—yet?

"One of the critical factors in organ preservation is likely to be temperature stability," says Hirsh. "It's not going to be the whole answer, of course, but keeping things steady might add some storage time. Maybe a lot of time."

That hopeful observation stems from a discovery by Hirsh that sugars in cell fluids of poplar tissue will crystallize when cold-storage temperatures fluctuate over a wide range, even if the change occurs slowly.

Such crystallization contradicts the assumption that extremely hardy, dormant tissue like that of poplar twigs is fully resistant to slow, subzero temperature changes—regardless of the range of fluctuation.

Experiments by Hirsh show that taking poplar twigs from 0°C to minus 70°C and back again several times at only 3°C per hour will cause sugar within the poplar cells to crystallize.

"No one had even suspected that this would occur," says Hirsh, "and without the EML images we might never have seen the evidence that loss of protective sugars leads to cellular membrane damage."

Sugars in cell fluids normally protect the cells against freeze injury, Hirsh explains. But the crystallization of sugars has the effect of removing them from the fluids. The result is a craterlike appearance formed by redistributed MAP's (membrane-associated particles, mostly lipids and proteins) on various internal membranes. This has been seen for the first time in Erbe's micrographs.

"Many scientists believe that sugars can effectively replace water on the internal membranes of cells dehydrated by freezing," Hirsh says. "In fact, recent theories on membrane protection depend on natural or artificially added sugars for that reason. Now we can see that it doesn't always happen that way if cell temperatures fluctuate."

Eric Erbe's electron micrographs also enabled Hirsh to see which membranes within the cells were most affected by temperature fluctuations.

"This kind of evidence is crucial to understanding the entire process of tissue destruction due to freezing," he says. "It allows us to directly see the damage in a living system, and it shows us where the damage is most likely to occur."

By keeping temperatures stable, Hirsh was able to store twigs from poplar trees at -4°F for 23 months without killing the cells. The previous record at that temperature was about 8 months.

"The implications for preserving human tissue are exciting," he says. "It's clear from electron micrographs that sugars can play a vital role in protecting cell membranes if storage temperatures are stable. But a lot more research is needed, and that means more imagery from the ARS Electron Microscopy Laboratory."—By **Stephen Carl Miller,** ARS.

*William P. Wergin and Eric F. Erbe are at the USDA-ARS Electron Microscopy Laboratory, Bldg. 177-B, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 504-9027.* ◆

## Measuring a Melon's Maturity While It's On the Vine

A gentle squeeze may help tell you if a melon's ready to eat. But it's still hard to say whether a slice will be tender and succulent or crunchy and bland.

To help ensure that more melons are sweet and juicy by the time they reach your table, Krista C. Shellie is studying the mysteries of melon ripening. But instead of a gentle squeeze, she gives fruit a jab with a long, thin needle.

Shellie, an ARS plant physiologist in Weslaco, Texas, uses a hypodermic needle to draw out gases from within the fruit's seed cavity—as the melon ripens on the vine.

"We want to see how gases associated with ripening—ethylene and carbon dioxide—change as the melons mature," explains Shellie, who is collaborating with Mikal E. Saltveit, a plant physiologist at the University of California at Davis.

"Currently, our understanding of melon ripening is based on changes in carbon dioxide and ethylene measured in harvested melons," says Shellie. This new study is the first to repeatedly sample the gases inside a still-growing melon.

Using a cylindrical, metal cork borer, she pokes small plugs out of young cantaloupes and honeydews, replacing them with nipple-shaped rubber stoppers. These sampling ports allow her to extract gases every other day without contaminating the fruit or disrupting its normal development.

In preliminary greenhouse studies, honeydew melons attached to the vine did not show the expected sharp rise in carbon dioxide concentration common in many ripening fruits. That rise—a direct result of increased respiration by the fruit—is known as a climacteric response.

"Instead, we saw a gradual rise in ethylene and a gradual decline in carbon dioxide as the melons matured," says Shellie. But she cautioned that further tests currently underway on melons growing outdoors are needed to confirm those initial results.

Shellie says the new technique could come in handy for scientists trying to measure the impact of new technologies aimed at improving melon ripening and storage.

"For instance," says Shellie, "we could use our repeat sampling technique to see how covering melons with shrinkwrap plastic, waxes, or edible films affects the fruit's respiration during storage." ARS researchers in Florida, Texas, and California have worked on different coatings designed to prolong the shelf life of various fruits.

"Also," she notes, "a clearer understanding of the ripening phenomenon could guide efforts to genetically engineer melons that would ripen on demand."—By **Julie Corliss,** ARS.

*Krista C. Shellie is in the USDA-ARS Crop Quality and Fruit Insects Research Unit, 2301 South International Blvd., Weslaco, TX 78596. Phone (512) 565-2647.*

## A New Natural Insecticide From Fungi

Environmentally friendly insecticides may be developed from fungal structures that repel fungi-eating insects.

Sclerotia look like tiny pepper specks inside a kernel of field corn. They're survival structures, and one of their suspected roles is to help the fungus fend off insects that feed on fungi and moldy crop residues in soil.

"Some sclerotia produce chemical compounds that naturally repel insects," says Donald T. Wicklow, ARS microbiologist at the National Center for Agricultural Utilization Research in Peoria, Illinois.

Wicklow has been growing the fungus *Aspergillus nomius,* harvesting the sclerotia, and providing samples to University of Iowa chemist James B. Gloer. From these, Gloer has isolated and purified a compound called nominine, which is just one of many compounds synthesized by fungal sclerotia.

To date, scientists have found about 10 insecticidal compounds made by the sclerotia of *A. nomius.* "Some of these are entirely new to science, and each has a different level of activity against insects," says Patrick F. Dowd, an ARS entomologist who tested the compounds.

Dowd prepared diets with 25 ppm concentration of nominine for insects—including corn earworms, *Helicoverpa zea.* He reports that after a week of eating the nominine-laced diet, 40 percent of the insects died. Survivors were made sick by the diet and grew poorly.

Dowd also tested the compound on the insects' "skin," or exoskeleton. As little as 2 micrograms (about 0.0001 ounce) caused them also to get sick and grow poorly.

An insecticide made from this compound could be effective on a range of agricultural insect pests that includes the corn earworm, cotton bollworm, tomato fruitworm, and tobacco budworm. The corn earworm and its cousin, the tobacco budworm, *Heliothis virescens,* are blamed for nearly $2 billion in agricultural damage each year.

Nominine acts specifically on insects as a gastrointestinal and contact poison. Tested on mice by an independent toxicology laboratory, it apparently had no significant effect at the dose administered. But the compound will still need to be reviewed and approved by the Environmental Protection Agency before any commercial use.

The researchers have obtained a patent for nominine's potential development as an environmentally friendly insecticide. Further development and commercial production are possible with methods already used in the fermentation industry, says Wicklow.

The research project is funded in part by the Biotechnology Research and Development Consortium in Peoria, Illinois, and by the National Science Foundation.—By **Linda Cooke,** ARS.

*For further information on Patent No. 5,017,598, "Nominine, An Insecticidal Fungal Metabolite," contact Donald T. Wicklow or Patrick F. Dowd, USDA-ARS National Center for Agricultural Utilization Research, 1815 N. University Street, Peoria, IL 61604. Phone (309) 685-4011.* ◆

U.S. Department of Agriculture
Agricultural Research Service
Room 318, B-005, BARC-West
10300 Baltimore Ave.
Beltsville, MD 20705-2350

Official Business
Penalty for Private Use $300

**To stop mailing** ☐
**To change your address** ☐
**Please return the mailing label from this magazine.**

Bulk Rate
Postage and Fees Paid
U.S. Department of Agriculture
Permit No. G-95

---

Superintendent of Documents Subscription Order Form

Order Processing Code:

**6130**

***Charge your order. It's Easy!*** MasterCard VISA

**To fax your orders (202) 512 2233**

☐ **YES,** enter my subscription as follows:

___subscriptions to **AGRICULTURAL RESEARCH** for $28.00 per year ($35.00 foreign).

The total cost of my order is $__________. Price includes regular domestic postage and handling and is subject to change.

**Call Order and Information Desk at (202) 783-3238 after 8/31/92 to verify prices.**

(Company or Personal Name) (Please type or print)

(Additional address/attention line)

(Street Address)

(City, State, ZIP Code)

Daytime phone including area code)

(Purchase Order No.)

YES NO
**May we make your name/address available to other mailers?** ☐ ☐

**Please choose method of payment:**

☐ Check payable to the Superintendent of Documents
☐ GPO Deposit Account
☐ VISA or MasterCard Account

(Credit card expiration date)

***Thank you for your order!***

(Authorizing Signature)

Mail To: New Orders, Superintendent of Documents
P.O. Box 371954, Pittsburgh, PA 15250-7954